DRAFT
Sampling and Analysis Plan
Berths 44 through 60
Sediment Verification Testing
Port of Los Angeles
San Pedro, California

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LIST OF ACRONYMS AND ABBREVIATIONS

AMEC	AMEC Earth & Environmental, Inc.
^{o}C	degree Celsius
Calscience	Calscience Environmental Laboratories
CRG	CRG Marine Laboratories
CSTF	Los Angeles Contaminated Sediments Task Force
DGPS	differential global positioning system
EC_{50}	Median Effects Concentration
EPA	U.S. Environmental Protection Agency
ERM	effects-range median
ERL	effects-range low
ft	foot/feet
ITM	Inland Testing Manual
mg/kg	milligrams per kilogram
MLLW	mean lower low water
NBS	National Bureau of Standards
NOAA	National Oceanographic and Atmospheric Administration
OPR	ongoing precision and recovery
oz	ounce
PAH	polycyclic aromatic hydrocarbon
PCB	polychlorinated biphenyl
Port	Port of Los Angeles
QA/QC	Quality Assurance/Quality Control
SAP	Sampling and Analysis Plan
TOC	total organic carbon
TRPH	total recoverable petroleum hydrocarbons
TEG	TEG Oceanographic Services, Inc.
USACE	U.S. Army Corps of Engineers

1.0 INTRODUCTION

The Port of Los Angeles (Port) has conducted several investigations of the sediments offshore Berths 44 through 60 in the southwestern portion of the Port (e.g., AMEC 2001, 2003a,b). Sediments contaminants were characterized relative to adjacent site activities, including copper and total organic carbon (TOC), in the vicinity of Berths 44 through 60. Biological exposure testing was also undertaken offshore Berths 48 through 52. Results of the above studies and other available data were presented to the Los Angeles Contaminated Sediments Task Force (CSTF) Advisory Committee on 18 March 2003, which unanimously agreed to recommend a target removal level based on the committee's best professional judgment (CSTF 2003).

Sediments with copper concentrations exceeding 254 milligrams per kilogram (mg/kg) (dry weight) were determined to be sufficiently elevated to establish a target removal goal (CSTF 2003). All sediments overlying the native Malaga Mudstone Formation within an area modeled to exceed the removal target were dredged in summer 2003. Dredging was undertaken in conjunction with the U.S. Army Corps of Engineers (USACE)/Port joint-sponsored Port of Los Angeles Main Channel Deepening Project, with the exception of sediments in the vicinity of Berth 57 where two dry docks were moored. These dry docks have subsequently been removed and dredging in this area is scheduled to proceed during the spring of 2006. Sediments were disposed at the Southwest Slip Confined Disposal Facility in the vicinity of Berths 106 through 117.

In consultation with the CSTF Advisory Committee, the Port agreed to conduct a sediment removal verification testing program. According to the final CSTF meeting record, the verification program was to involve a study "along the fringes of the dredged area…within one year of completion of dredging" (CSTF 2003). AMEC Earth & Environmental, Inc. (AMEC) has been contracted by the Port to conduct the sediment removal verification testing effort.

This Sampling and Analysis Plan (SAP) details the testing program to be conducted in the vicinity of the area dredged in 2003 to satisfy the CSTF's post-dredge verification testing recommendation. This study will be conducted according to the U.S. Environmental Protection Agency (EPA)/USACE guidance document entitled *Evaluation of Dredged Material Proposed for Discharge in Waters of the U.S.* (*Inland Testing Manual* [ITM]) (EPA/USACE 1998), which has been used to guide earlier phases of the project prior to dredging. The approach (further described below) will be phased and include sediment chemistry testing as well as bioaccumulation exposure testing.

This study will include the following elements:

- Preparation of a final SAP for CSTF Advisory Committee review
- Collection of test and reference sediment samples according to SAP and ITM protocol
- Chemical analysis of sediment samples for copper and TOC
- Copper bioaccumulation exposure studies using the clam *Macoma nasuta*
- Data analysis and reporting

- Presentation of the study results to the CSTF Advisory Committee

2.0 SITE HISTORY

2.1 BERTHS 57 AND 58 – MEC 1994

A four-core composite Green Book (EPA/USACE 1991) Tier III study performed at Berths 57 and 58 (MEC 1994) found elevated concentrations of trace metals, total recoverable petroleum hydrocarbons (TRPH), DDT (and derivatives), polychlorinated biphenyls (PCBs), and total polycyclic aromatic hydrocarbons (PAHs) in the sediment. Statistical test results indicated the lack of statistically significant toxic effects in solid and suspended particulate phase tests with the exception of the bivalve larvae development test. However, the median effects concentration (EC_{50}) was greater than 100 percent and therefore the Green Book limiting permissible concentration requirement for ocean disposal for suspended particulates was met. Bioaccumulation results indicated statistically significant elevated concentrations of cadmium, copper, lead, and PAHs in the clam tissues and PAHs in the worm tissues. Sediments were not dredged.

2.2 BERTHS 40 THROUGH 44 – OGDEN 1995

A six-core sediment chemistry study was performed at Berths 40 through 44 using a vibracore (Ogden 1995a). The results indicated several metals (copper, lead, nickel, mercury, and arsenic) were elevated above effects range-median (ERM) values. Several individual PAH and total PAHs were also detected at elevated levels. DDT and its derivatives were detected, but only 4,4'-DDE values were elevated. Organotins were detected in five of the six samples. Sediments remain on-site.

2.3 BERTHS 45 THROUGH 47 – OGDEN 1995

A two-site Green Book Tier III test was conducted at Berths 45 through 47 to characterize the sediment for dredging (Ogden 1995b). No significant toxicity was found in the solid phase or in two of the three suspended particulate phase bioassay tests. Low levels of toxicity were observed in the bivalve larvae development test. Bioaccumulation of copper, arsenic, selenium, and cadmium was statistically significant in worm and clam tissues. Low levels of PAHs were found in clam tissue at both sites. The sediment was recommended for ocean disposal. The sediments were dredged during 1996 and 1997 and disposed of at the LA-2 ocean dredged material disposal site.

2.4 BERTHS 51 THROUGH 55 – KINNETIC 1996

In 1996, a sediment characterization study was performed at Berths 51 through 55 (Kinnetic Laboratories 1996). The metals arsenic, cadmium, chromium, copper, lead, mercury, nickel, selenium, silver, and zinc were detected in the study. Concentrations of the metals selenium and silver were elevated. High concentrations of the pesticide derivative 4,4'-DDE and PAHs were detected. Aroclors 1254 and 1260 (PCBs) were

detected and total PCB concentrations were significantly elevated. Two composite samples were analyzed and it was determined that upland disposal was appropriate (sediment was disposed at the Anchorage Road sediment storage site in 1999).

2.5 BERTHS 45 THROUGH 47 – OGDEN 1997

In a subsequent study of Berths 45 through 47 sediments (Ogden 1997) (see Section 2.3), one composite sample was collected just offshore the berthing area and another composite sample was taken farther offshore of the berths. Although there was no significant toxicity found in five of the six bioassay tests, elevated PAH concentrations, high mercury, copper, and zinc concentrations in sediment, and statistically significant bioaccumulation of cadmium, copper, arsenic, selenium, and PAHs in worms and clams indicated that the sediment was unsuitable for ocean disposal. Sediments were not dredged and remain at the site.

2.6 WATCHHORN BASIN (BERTHS 41 THROUGH 43) – MEC 1998

A Tier III sediment characterization study of the Watchhorn Basin (MEC 1998) identified 12 core samples with elevated metals concentrations (arsenic, cadmium, copper, mercury, nickel, selenium, silver, and lead). Individual PAH concentrations were low when compared to reference material values, but total PAH values were considered elevated. No statistically significant toxicity was observed in the bioassay or bioaccumulation tests. Sediments remain on-site.

2.7 FORMER KAISER TERMINAL – AMEC 2001

A study was conducted along Berths 48 through 53 to determine the extent of contamination due to product release (e.g., coal, petroleum coke, and copper ore) from the dry bulk terminal (AMEC 2001). It was determined that sediment in the areas east and southeast of the terminal contained elevated levels of TOC and copper, especially along the wharf face and on the south end of the mole pier. The report included modeled copper and TOC isopleths (lines corresponding to specific concentrations). Sediments exceeding 254 mg/kg copper were dredged in 2003.

2.8 BERTHS 48 THROUGH 52 SUPPLEMENTAL STUDY – AMEC 2003

A seven-sample Tier III sediment characterization was performed in the area adjacent to Berths 48 through 52 relative to a nearby reference location (AMEC 2003a). No statistically significant toxicity was observed in the solid phase or suspended particulate phase bioassay tests. There was, however, statistically significant bioaccumulation of copper in clam tissues for exposures to sediments with concentrations greater than 233 mg/kg. Sediments exceeding 254 mg/kg copper were dredged in 2003.

2.9 EXPANDED SEDIMENT CHARACTERIZATION STUDY – AMEC 2003

A sediment characterization study was undertaken offshore Berths 44 through 47 and Berths 53 through 57 (AMEC 2003b) to augment previously collected data (AMEC

2001). Copper and zinc concentrations were observed to be elevated off Berths 44 through 47, especially in the vicinity of the marine railway at Berth 44 (maxima of 9,560 mg/kg and 1,150 mg/kg, respectively). Additional analytes observed to be elevated included organotins, mercury, and PAHs.

Elevated copper levels (maximum of 780 mg/kg) were found in the vicinity of Berth 57, an area that had formerly hosted dry dock activities. Additional analytes found to be elevated in the East Channel included organotins and PAHs. Sediments exceeding 254 mg/kg copper were dredged in 2003 or are scheduled for removal in Spring 2006.

3.0 METHODS AND MATERIALS

AMEC will be responsible for collection and documentation of all field efforts. Nautilus Environmental's San Diego Aquatic and Terrestrial Toxicology Laboratory (Nautilus) will conduct the bioaccumulation exposure tests. The following subcontractors will be used in support roles: Seaventures will supply boat, dredge, and positioning services; TEG Oceanographic Services will supply coring equipment; Calscience Environmental Laboratories (Calscience) will conduct chemical analyses on bulk sediment samples; and CRG Marine Laboratories (CRG) will conduct bioaccumulation exposure tissue analyses. Key project personnel are listed in Table 1.

Table 1. Key Project Personnel

Organization	Name	Title	Office Phone	Mobile Phone
Port of Los Angeles	Kathryn Curtis	Port Project Manager	310-732-3681	
AMEC	Barry Snyder	AMEC Project Manager	858-458-9044 ext. 270	858-354-8340
AMEC	Nick Buhbe	Field Collection Manager	858-458-9044 ext. 254	619-985-9111
Nautilus Environmental	Chris Stransky	Nautilus Laboratory Manager	858-587-7007	858-775-5547
Seaventures	Kenny Nielsen	Captain, M/V *Early Bird*	949-637-2433	949-637-2433
TEG Oceanographic Services	Mark Mertz	Vibracore Contractor	831-684-2749	408-499-8646
Calscience Environmental Laboratories	Bob Sterns	Laboratory Director	714-895-5494	
CRG Marine Laboratories	Richard Gossett	Laboratory Director	310-533-5003	

3.1 PROJECT APPROACH

Within the dredge footprint, all materials above the native Malaga Mudstone formation have been dredged and disposed (with the exception of the Berth 57 area). The phased approach described here will be used to assess the success of the removal of sediments with copper levels that exceeded 254 mg/kg along the fringes of the dredge footprint. Sampling efforts will include collecting sufficient volumes of sediment for bulk chemistry and bioaccumulation exposure testing from all 15 locations in the vicinity of the dredge footprint (Figure 1). All 15 sediment samples will be tested for bulk sediment copper and TOC concentrations. The resulting data will be used to select a subset of locations that will undergo subsequent bioaccumulation studies. This approach will require quick turnaround times for the bulk chemistry analyses in order to initiate bioaccumulation studies within the requisite holding time (6 weeks).

Three criteria will be used to select the locations for bioaccumulation exposure testing: 1) three sediment samples with the overall highest copper concentrations will be tested; 2) at least three sediment samples from the Berths 48 through 52 area will be tested; and 3) at least one sample from each of the Berths 44 through 47 and Berths 53 through 57 areas will be tested. If the three samples with the highest copper concentrations are found within the Berths 48 through 52 area, this design will require that a minimum of five test sediments be selected for bioaccumulation exposure. A maximum of seven bioaccumulation exposures will be required if the three highest copper concentrations are detected in sediments at either Berths 44 through 47.

Reference sediments will be collected and tested concurrently with test sediments. Control tissue samples will also be tested to provide an additional source of baseline data.

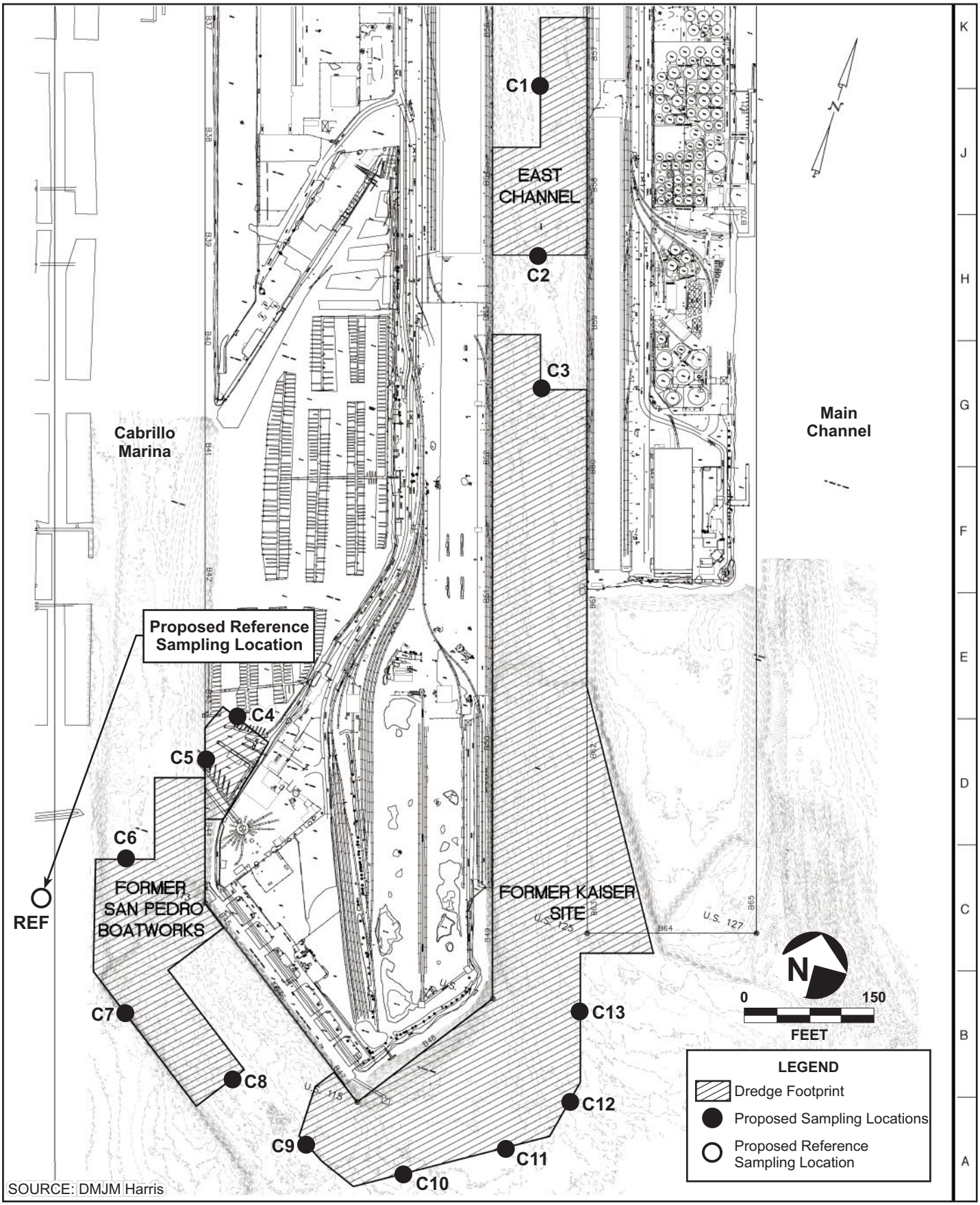
3.2 SEDIMENT COLLECTION

3.2.1 Proposed Collection Locations

The proposed study site with the 15 test-sediment sampling locations and single reference sample location is shown in Figure 1. The reference location was selected as an area within the Port with sediment characteristics similar to those present within the study site but absent proximal sources of contamination (i.e., large industrial or stormwater inputs). The reference site was previously sampled by the Port as part of previous sediment characterization efforts. Sediment characteristics indicate that it is a valid reference location with respect to both contaminant concentrations and biological testing.

3.2.2 Sediment Collection Methods

A differential global positioning system (DGPS) will be used to navigate to the predetermined sampling locations (Table 2). The water depth will be measured using



Berths 44 through 60
Confirmation Sampling Locations
Port of Los Angeles

FIGURE

1

GRAPHICS2/3151/4151001004_POLA/ConfirmationSampling06.fh8

Table 2. Sampling Location Positions

Sample ID	North Latitude	West Longitude
C1	33°43.5060	118°16.5369
C2	33°43.3901	118°16.4918
C3	33°43.3104	118°16.4605
C4	33°43.0396	118°16.6193
C5	33°43.0076	118°16.6245
C6	33°42.9262	118°16.6551
C7	33°42.8484	118°16.6342
C8	33°42.8224	118°16.5271
C9	33°42.8059	118°16.4550
C10	33°42.8113	118°16.4002
C11	33°42.8404	118°16.3401
C12	33°42.8803	118°16.2934
C13	33°42.9329	118°16.3058
C1	33°43.5060	118°16.5369
C2	33°43.3901	118°16.4918
Reference	33°42.891	118°16.708

vessel sonar and corrected to mean lower low water (MLLW) using National Oceanic and Atmospheric Administration (NOAA) tide tables and compared to bathymetric survey maps provided by the Port.

TEG personnel will deploy the vibracore used for sediment sample collection. The vibracore uses a 4-inch-diameter aluminum tube connected to a stainless steel cutter. The aluminum-encased vibrating unit uses 240-volt, 3-phase, 26-amp electricity to drive two outer-rotating vibrators. The vibracore's head and tube are lowered by a hydraulic winch and vibrated until the desired depth is achieved. For this project, since there is no established project depth, a maximum of the top 4 feet of material will be retained as samples. Core penetration depth will be calculated with a tape measure attached to the vibracore's head. After the vibracore is turned off, the sediment core will be returned to the boat's deck for processing. If debris is encountered during the collection process at a particular site, a field decision will be made to relocate to a sampling location within the footprint that is free of debris.

3.2.3 Sample Logging and Handling

Core samples will be photographed and logged immediately following sampling. Large debris and live organisms will be noted in logs and discarded. The following information

will be recorded during the test sediment collection program in a project-specific field log:

- Date and time of collection
- Sample identification code
- Sampling location (latitude/longitude to within a 3-meter accuracy)
- Water depth (± 0.1 ft)
- Tidal stage
- Meteorological conditions
- Sampling method and any problems encountered (e.g., debris)
- Description of the material type obtained in the samples
- Note of any Malaga Mudstone encountered (either in the sample or a core tube exterior smear)
- Note of any live organisms in samples
- Description of sediment subsampling methods
- Notation regarding photographic record for each core

Samples will be thoroughly homogenized using an electric drill-driven impeller and subsampled for bulk chemical analyses. The samples for chemical analyses will be stored in labeled 16-oz glass jars with Teflon-lined lids in iced coolers. A larger sample (approximately 5 gallons) will be retained for biological testing and handled similarly, with the exception that large volume sediment samples will be stored in clean polyethylene bag-lined 5-gallon buckets under block or crushed ice. The 16 individual chemistry samples will be sent by courier to Calscience at the end of each sampling day or shortly thereafter. The large-volume samples will be transported to Nautilus's San Diego laboratory under ice and promptly brought to 4 degrees Celsius (°C).

The integrity of each sample from the time of collection to the point of data reporting will be maintained throughout the study. Proper record keeping and chain-of-custody procedures will be implemented to allow samples to be traced from the time of collection to their final disposition. After collection of sediments, documentation on various logs and forms will be required to adequately identify and catalog the sample location and other relevant information.

Sample container identification information will be recorded on the chain-of-custody form. The chain-of-custody forms will also identify the project, sampling organization, point of contact, sample collection date and time, and type of sample. The form will also serve as a sample analysis request form. Samples will be sent to the laboratories along with chain-of-custody forms specifying the sample identifiers and the analyses to be conducted. These forms will be prepared in triplicate; the field supervisor will retain one copy, and the other two copies will accompany the shipment.

Proper completion of all chain-of-custody documentation will be the responsibility of the field manager. Chain-of-custody forms will be completed and signed before the end of

each sampling day and before the samples are removed from the vessel or pass from the control of the field manager. Chain-of-custody forms will be signed at each additional point of transfer of samples between the field and the laboratory as well as within the laboratory. A complete set of samples (8-oz volumes) will be archived frozen for possible future chemistry testing.

3.3 PHYSICAL AND CHEMICAL ANALYSES

The 16 sediment samples (15 site and one reference) will be tested for copper and TOC. Calscience will conduct all analytical chemistry analyses according to EPA/USACE-approved methods for the constituents listed in Table 3.

3.4 BIOACCUMULATION EXPOSURE TESTING AND ANALYSES

Test organisms used in the bioassay and bioaccumulation tests either will be collected in areas known to be generally free of pollutants or purchased from reputable culturists. Organisms are purchased from vendors who are screened by their reputation, depth of knowledge, and their ability to consistently deliver healthy test organisms. Upon receipt in the bioassay laboratory, test organisms will be slowly acclimated to test conditions in environmentally controlled holding areas. Acclimation is performed in accordance with each test protocol; test organisms are evaluated on a performance basis for every test conducted in the laboratory.

Bioaccumulation testing will be performed using the bent-nose clam (*Macoma nasuta*) over a 28-day test period under flow-through conditions. Tests will be initiated with the addition of at least a 2-centimeter layer of test, reference, or control sediment to aquaria, which have been designed to accommodate the clams necessary to yield the biomass required to achieve the specified detection limits. The chambers will be maintained under flow-through conditions and each chamber's water quality will be measured daily.

Upon test termination, the test, reference, and control sediments will be sieved to remove the clams. Surviving animals will be placed, by replicate, in an aquarium and held under flow-through conditions to depurate for 48 hours. Sediments eliminated by the animals during depuration will be removed daily. Following depuration, animals will be carefully removed from the holding chambers and placed in labeled, zipper-sealed plastic storage bags to be frozen. Each bag will be assigned a random number. Frozen test tissue will be transported to the analytical laboratory for chemical analyses. As an additional quality control measure and to provide additional baseline data, a pre-test tissue sample will be analyzed.

Percent solids and copper analyses will be undertaken on the bioaccumulation tissue samples. Target reporting limits are listed in Table 3.

Table 3. Physical and Chemical Analyses for Sediment and Elutriate Samples

Analyte	Preparation Method	EPA Analysis Method	Sediment Target Reporting Limits[a]	Tissue Target Reporting Limits[b]
Total Solids	-	160.3	0.1%	0.1%
Total Organic Carbon	Acidify to release carbonates	9060	0.01%	-
Copper	3051[c]	6020[c]	0.1 (mg/kg)	1.0 (mg/kg)

[a] Sediment minimum detection limits are on a dry-weight basis.
[b] Reporting limits provided by CRG Marine Laboratories, Inc.
[c] SW-846, Test Methods for Evaluating Solid Waste, 3rd Edition.

3.5 ANALYTICAL QA/QC

Quality assurance/quality control (QA/QC) will be maintained during the analytical portion of this study by using duplicate sample analyses, reagent blanks, and spiked samples as specified in the EPA methods for individual analytes (Table 3). All QA/QC information will be included with the draft and final testing reports. Detection limit targets are specified for sediments in the ITM (EPA/USACE 1998). Replicate analyses for each type of determination are performed on each type of sample matrix. Precision is expressed as the difference in results of replicate analyses ("analysis" includes all steps of preparation and determination) divided by the average of those values and expressed as a percentage. Thus, a relative percent difference of 0 percent means that replicate results were identical. Instrumental calibration and verification are done using EPA and/or National Bureau of Standards (NBS) traceable reference materials. Quality control requirements for this study are outlined in Table 4 and Table 5. Measurement objectives are presented in Table 6.

DATA ANALYSIS

4.1 PHYSICAL AND CHEMICAL ANALYSES RESULTS

The bulk sediment results will be compared to available sediment quality guidelines (e.g., effects-range low [ERLs] and ERMs) and to the removal target of 254 mg/kg copper to determine the relative chemical loading in the sediments.

4.2 BIOACCUMULATION ANALYSES RESULTS

Tissue copper levels will be compared to three data: 1) the reference sediment exposure data generated in this study; 2) the control tissue data generated in this study (both sediment exposures and pre-test); and 3) the bioaccumulation data generated previously for the Berths 48 through 52 study (AMEC 2003a). With regard to data generated in this study, one-tailed *t*-tests will be used to compare tissue copper concentration data between test sediment and reference sediment exposures in cases

Table 4. Minimum Laboratory Quality Control

Analysis Type	Method Blanks	Duplicates	Precision and Recovery	Matrix Spike	Matrix Spike Duplicate
Total Solids	X	X	X		
TOC	X	X	X		
Copper	X	X	X	X	X

Table 5. Acceptance Limits and Corrective Actions for Minimum Quality Control

QC Category	Acceptance Limits	Corrective Action
Method Blank	<2.2X method detection limit or 0.10X analyte level	Correct source of contamination, obtain acceptable blank values, and prepare fresh aliquots of the samples and reanalyze.[1]
Duplicate relative standard deviation	25 percent	
Ongoing precision and recovery (OPR)	18 percent	The source of the problem must be identified and resolved before continuing analyses. Prepare fresh aliquots of the samples and reanalyze. [1]
Matrix spike and matrix spike duplicate	35 percent	If MB and OPR are in control, the problem is judged to be matrix related, not system related. Evaluate need to perform method of standard addition (MSA) or the data need to be qualified as suspected matrix effect. [1]
Matrix spike and matrix spike duplicate relative standard deviation	25 percent	

[1] Any matrix spike, surrogate, or OPR results outside of the control limits will be evaluated by the laboratory.
[2] Calscience and CRG will calculate in-house performance criteria for matrix spike recoveries and surrogate recoveries.

MB – method blank
MDL – method detection limit
MS – matrix spike
MSD – matrix spike duplicate
OPR – ongoing precision and recovery
RSD – relative standard deviation

Table 6. Measurement Quality Objectives for Chemical Analyses

Constituent	Units (dry wt)	MDL	Accuracy	Duplicate Frequency	Precision	Frequency
Copper	mg/kg	0.1	±20 percent	1/batch	≤20 percent	1/batch
TOC	percent	0.1	±20 percent	1/batch	≤20 percent	1/batch

MDL – method detection limit
mg/kg – milligrams per kilogram
TOC – total organic carbon

where the test data concentrations are higher than the reference sediment exposure data. Following that exercise, the results of this study will be put in the context of control tissue data and the exposure data previously generated for the Berths 48 through 52 study (AMEC 2003a).

5.0 REPORT PREPARATION

The draft and final study reports will contain the following information:

- Introduction – the project description and a dredge history of the site, historical uses, results of previous toxicity or sediment work, known contamination or discharges, and other general information
- Site Maps – the test sediment collection locations and location of water collection used to prepare elutriate
- Methods and Materials – all information pertaining to test sediment collection, handling, and bulk sediment and elutriate sample preparation
- Results – results from all physical and chemical analyses
- Discussion – a detailed description of the chemical and physical characteristics of the test sediments
- References
- Core Log – core collection coordinates, target/actual recovery, and sediment characteristics (e.g., strata, color, odor)
- Photographic Documentation
- Quality Assurance/Quality Control Information – laboratory matrix spike and recovery, surrogate recovery, and method blank data

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